

# Single cell lithium ion /lithium polymer battery protection compozite IC

**CT2105**

*Standard lead-free products*

## 1. Product Overview

CT2105 is a composite high-precision single-cell lithium-ion/lithium polymer battery protection IC. It integrates the switching MOSFET into the IC based on the traditional battery protection circuit; it has overcharge voltage and current protection, over-discharge voltage and current protection, overheating protection, short circuit protection, cell reverse connection protection and charger reverse connection protection. Protection and other functions, and the power consumption is very low when working.

## 2. Characteristics (important parameters)

- 2.1 Built-in low-impedance MOSFET (equivalent to 58mΩ RDS(ON));
- 2.2 High-precision voltage detection: Overcharge voltage detection accuracy: ±50mV; Over-discharge voltage detection accuracy: ±50mV;
- 2.3 Triple over-current detection protection: overdischarge current 1, over-discharge current 2 and load short-circuit detection current;
- 2.4 Built-in delay circuit, the delay time is generated by the built-in circuit. No external capacitor is required;
- 2.5 Low current consumption, working mode: maximum 4.0μA; sleep mode: maximum 0.1μA;
- 2.6 Battery reverse connection protection is safer;
- 2.7 he application is extremely simple: only one capacitor needs to be connected to the periphery;
- 2.8 Over-temperature protection function;
- 2.9 Charger detection function;
- 2.10 Short circuit protection function;
- 2.11 Charger reverse connection protection function;
- 2.12 SOT23-6 package, compliant with European "ROHS"

## 3. Package pins and description

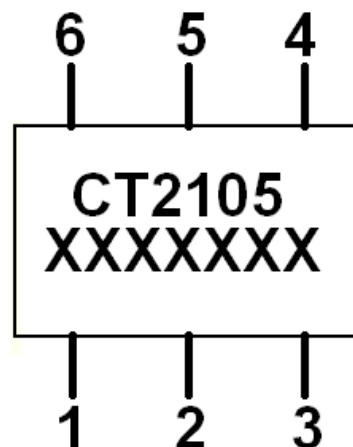


Figure 3.1

SOT23-6 package, refer to the application circuit diagram.

Table 3.1

| SOT23-6 package pin description |      |                                                                              |
|---------------------------------|------|------------------------------------------------------------------------------|
| Pin number                      | Name | Function description                                                         |
| 1                               | VM   | Charger is positive input; overcurrent detection end                         |
| 2                               | GND  | The grounded end; connect the negative electrode of the battery core         |
| 3                               | TIN  | Internal test and use; actual application ground                             |
| 4                               | VCC  | Internal circuit power supply terminal                                       |
| 5                               | GND  | The grounded end; connect the negative electrode of the core                 |
| 6                               | VDD  | Positive power input terminal; connecting the positive electrode of the core |

## 4. Marking

**CT2105**  
 {  $\frac{XX}{\text{Year}}$   $\frac{XXXXX}{\text{Serial number}}$

## 5. Electrical parameters

**Table 5.1**

**Note:** Unless otherwise specified, the indicators listed in ordinary fonts refer to the operating temperature  $T_a = 25^{\circ}\text{C}$ ; the indicators listed in bold font refer to the operating temperature  $T_a = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

| Parameter                                             | Symbol      | Test conditions               | Min. value     | Typ. value     | Max. value     | Unit    |
|-------------------------------------------------------|-------------|-------------------------------|----------------|----------------|----------------|---------|
| Detection voltage                                     |             |                               |                |                |                |         |
| Overcharge detection voltage (up)                     | $V_{CU}$    |                               | 4. 225         | 4. 275         | 4. 325         | V       |
|                                                       |             |                               | 4. 200         | 4. 275         | 4. 350         |         |
| Overcharge hysteresis voltage                         | $V_{HC}$    |                               | 175            | 200            | 225            | mV      |
|                                                       |             |                               | 175            | 200            | 225            |         |
| Over discharge detection voltage (low)                | $V_{DL}$    |                               | 2. 450         | 2. 500         | 2. 550         | V       |
| Overdischarge hysteresis voltage                      | $V_{HD}$    |                               | 375            | 400            | 425            | mV      |
|                                                       |             |                               | 350            | 400            | 450            |         |
| Charger detection voltage                             | $V_{CHA}$   |                               | $V_{DD}+0. 07$ | $V_{DD}+0. 12$ | $V_{DD}+0. 2$  | V       |
|                                                       |             |                               | $V_{DD}+0. 02$ | $V_{DD}+0. 12$ | $V_{DD}+0. 25$ |         |
| Load short circuit detection voltage                  | $V_{SHORT}$ | $V_{DD} = 3. 5V$              | 1. 20          | 1. 25          | 1. 30          | V       |
|                                                       |             |                               | 1. 15          | 1. 25          | 1. 35          |         |
| Detection current                                     |             |                               |                |                |                |         |
| Overcharge detection current                          | $I_{OCC}$   | $V_{DD} = 3. 5V$              | 2. 1           | 3. 0           | 3. 9           | A       |
|                                                       |             |                               | 1. 9           | 3. 0           | 4. 1           |         |
| Overdischarge current 1 detection current             | $I_{ODC1}$  | $V_{DD} = 3. 5V$              | 2.5            | 3.5            | 4.5            | A       |
|                                                       |             |                               | 2.3            | 3.5            | 4.7            |         |
| Overdischarge current 1 detection current             | $I_{ODC2}$  | $V_{DD} = 3. 5V$              | 4.5            | 6.0            | 7.0            | A       |
|                                                       |             |                               | 4.0            | 6.0            | 8.0            |         |
| Current consumption                                   |             |                               |                |                |                |         |
| Current consumption under normal operating conditions | $I_{OPE}$   | $V_{DD} = 3.5V$ , VM unloaded | 1. 0           | 2. 0           | 3. 0           | $\mu A$ |
|                                                       |             |                               | 0. 7           | 2. 0           | 4. 0           |         |

|                                    |           |                               |     |     |     |         |
|------------------------------------|-----------|-------------------------------|-----|-----|-----|---------|
| Current consumption in sleep state | $I_{DDQ}$ | $V_{DD} = 2.0V$ , VM unloaded | --- | --- | 0.1 | $\mu A$ |
|------------------------------------|-----------|-------------------------------|-----|-----|-----|---------|

**Table 5.2**

| Parameter                                       | Symbol               | Test conditions                              | Min. value | Typ. value | Max. value | Unit |
|-------------------------------------------------|----------------------|----------------------------------------------|------------|------------|------------|------|
| VM terminal - internal resistance               |                      |                                              |            |            |            |      |
| Internal resistance between VM and VDD          | R <sub>VMD</sub>     | V <sub>DD</sub> = 3.5V<br>VM = 1.0V          | 12         | 20         | 30         | K Ω  |
|                                                 |                      |                                              | 10         | 25         | 40         |      |
| Internal resistance between VM and GND          | R <sub>VMS</sub>     | V <sub>DD</sub> = 2.0V<br>VM = 1.0V          | 300        | 450        | 675        | K Ω  |
|                                                 |                      |                                              | 225        | 450        | 900        |      |
| FET impedance                                   |                      |                                              |            |            |            |      |
| FET equivalent resistance                       | R <sub>DS (ON)</sub> | V <sub>DD</sub> =4.0V, I <sub>VM</sub> =1.0A | –          | 58         | 60         | m Ω  |
| Over temperature protection                     |                      |                                              |            |            |            |      |
| Overtemperature protection                      | T <sub>SHD+</sub>    |                                              | 105        | 120        | 135        | ℃    |
| Overtemperature protection recovery temperature | T <sub>SHD–</sub>    |                                              | 75         | 90         | 105        |      |
| Detection delay time                            |                      |                                              |            |            |            |      |
| Overcharge voltage detection delay time         | t <sub>CU</sub>      |                                              | 0.96       | 1.20       | 1.40       | S    |
|                                                 |                      |                                              | 0.70       | 1.20       | 2.00       |      |
| Overdischarge voltage detection delay time      | t <sub>DL</sub>      |                                              | 115        | 144        | 173        | mS   |
|                                                 |                      |                                              | 80         | 144        | 245        |      |
| Overdischarge current 1 detection delay time    | t <sub>ODC1</sub>    | V <sub>DD</sub> = 3.5V                       | 8.8        | 11.0       | 13.2       | mS   |
|                                                 |                      |                                              | 6.5        | 11.0       | 15.0       |      |
| Overdischarge current 2 detection delay time    | t <sub>ODC2</sub>    | V <sub>DD</sub> = 3.5V                       | 4.40       | 5.50       | 6.60       | mS   |
|                                                 |                      |                                              | 3.00       | 5.50       | 9.30       |      |
| Load short circuit detection delay time         | t <sub>SHORT</sub>   | V <sub>DD</sub> = 3.5V                       | 288        | 360        | 432        | μS   |
|                                                 |                      |                                              | 216        | 360        | 576        |      |
| Overcharge current detection delay time         | t <sub>OCC</sub>     | V <sub>DD</sub> = 3.5V                       | 8.8        | 11.0       | 13.2       | mS   |
|                                                 |                      |                                              | 6.5        | 11.0       | 15.0       |      |

## 6. Working conditions

Table 6.1: Recommended operating range

| Parameter                                          | Symbol           | Min. value | Max. value | Unit |
|----------------------------------------------------|------------------|------------|------------|------|
| Supply voltage (voltage between VDD and GND)       | VDD              | 2.0        | 5.0        | V    |
| Charger input voltage (voltage between VM and GND) | VM               | -0.3       | 5.5        | V    |
| Operating temperature range                        | T <sub>OPR</sub> | -40        | 85         | °C   |

## 7. Maximum ratings

| Parameter                                          | Symbol            | Min. value | Max. value | Unit |
|----------------------------------------------------|-------------------|------------|------------|------|
| Supply voltage (voltage between VDD and GND)       | VDD               | 0          | 8.0        | V    |
| Charger input voltage (voltage between VM and GND) | VM                | -0.3       | 5.5        | V    |
| Junction temperature                               | T <sub>JMAX</sub> | ----       | 150        | °C   |
| Storage temperature range                          | T <sub>SG</sub>   | -55        | 125        | °C   |
| Power dissipation                                  | P <sub>MAX</sub>  | ----       | 400        | mW   |

**Note:** The limit parameters are the limit parameter range under abnormal working conditions (static). Working within this range of CT2105 may cause permanent damage to the circuit itself. When applying, please set the working conditions according to the parameter range provided in the “Recommended operating range”.

It is not recommended to use CT2105 under conditions beyond the “Recommended operating range” because that may affect the overall reliability of the circuit.

## 8. Application circuit diagram

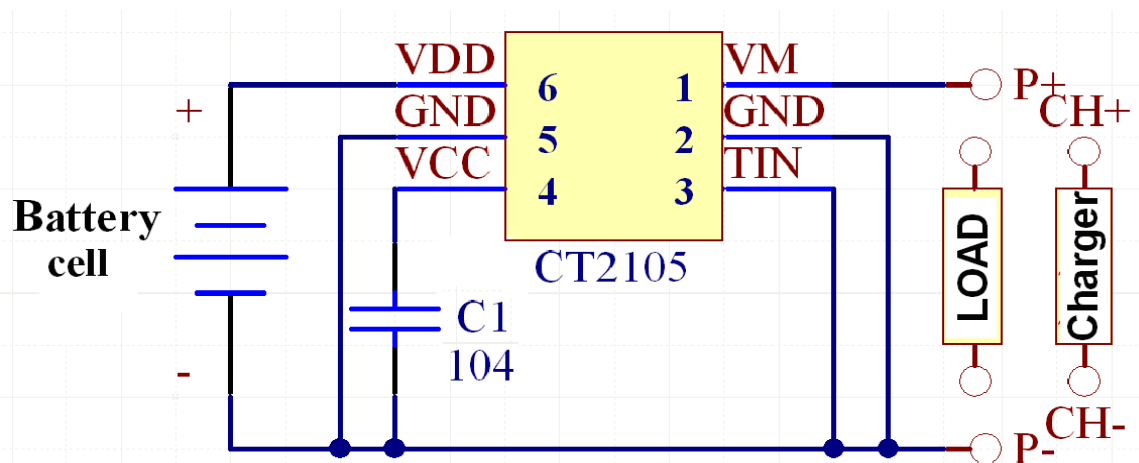


Figure 8.1

## 9. Working principle

CT2105 supports four working modes: normal working mode, charging working mode, discharging working mode and sleep working mode.

### 9.1 Normal working mode

Under normal conditions, CT2105 is powered by the battery core, and its V<sub>DD</sub> terminal voltage is between the overcharge detection voltage V<sub>CU</sub> and the overdischarge detection voltage.

Between  $V_{DL}$ , the VM terminal current is below the overcharge/overdischarge detection current. At this time, the internal switch is turned on normally, and the battery charging and discharging processes are freely switched.

**Note:**

When the battery cell is connected to CT2105 for the first time, even if the battery cell voltage is within the normal range, the circuit may still be in a protection state. At this time, short-circuit VM and VDD, or connect the battery to the charger, and the circuit can enter the normal state.

## 9.2 Overcharge voltage situation

Under normal conditions, the battery is being charged. When the cell voltage (i.e.  $V_{DD}$  terminal voltage, hereafter collectively referred to as  $V_{DD}$ ) exceeds the overcharge detection voltage  $V_{CU}$ , and the maintenance time exceeds the overcharge voltage detection delay time  $T_{CU}$ , the CT2105 internal switch is turned off. Disconnect the charging circuit to stop charging and enter the overcharge voltage protection state.

After entering the protection state, it can be restored to the normal state through the following two conditions:

- (1) When the charger is connected, the  $V_{DD}$  voltage drops to the overcharge detection recovery voltage  $V_{CL}$  (where  $V_{CL}=V_{CU}-V_{HC}$ );
- (2) When the charger is not connected, the  $V_{DD}$  voltage drops to the overcharge detection voltage  $V_{CU}$ . When the charger is not connected, the  $V_{DD}$  voltage is still higher than the overcharge detection voltage  $V_{CU}$ , and the battery will be discharged through the internal diode until the cell voltage is lower than  $V_{CU}$  and the circuit enters the normal state.

**Note:**

- a) In the case of overcharge voltage, when the charger is still connected, if the voltage at VM terminal is greater than or equal to the charger detection voltage  $V_{CHA}$ , even if the battery voltage is as low as the overcharge release voltage ( $V_{CL}$ ), the overcharge voltage condition still cannot be freed.
- b) In the case of overcharge voltage, when the battery core is not connected to the charger through the CT2105 built-in MOSFET, the input voltage of the charger must be lower than the maximum rated voltage  $V_{max}$  specified by the chip. Exceeding the maximum rated voltage  $V_{max}$  will damage the chip and battery.

## 9.3 Overcharge current situation

When the battery is in charging mode, if the charging current value exceeds the overcharge detection current value  $I_{OCC}$ , and the duration exceeds the overcharge current detection delay time  $t_{OCC}$ , the CT2105 will turn off the internal switch, disconnect the charging circuit, stop charging, and enter overcharge current protection state.

*Recovery conditions:* When the charger is disconnected or connected to the load, and the VM terminal voltage is lower than or equal to the charger detection voltage  $V_{CHA}$ , CT2105 automatically returns to the normal state from the overcharge current protection state.

#### **9.4 Over-discharge voltage situation**

Under normal conditions, the battery is discharged. When the cell voltage drops to the over-discharge detection voltage  $V_{DL}$  and the duration exceeds the over-discharge voltage detection delay time  $t_{DL}$ , the CT2105 will turn off the internal switch, cut off the discharge circuit to stop discharging, and enter the over-discharge detection voltage. In the voltage protection state, the voltage of the VM pin will be pulled down by the internal resistance  $R_{VMS}$  of the VM to ground. When the voltage between VM and ground is less than or equal to 1.5V (typical value), the current consumption of the entire battery will be reduced to the current consumption value  $I_{DDQ}$  in the sleep state and enter the sleep state.

*Recovery conditions:* When the battery is in over-discharge voltage protection state, the battery needs to be charged to restore the battery to normal state. Because the over-discharged battery may be in two states: one is when the  $V_{DD}$  voltage is greater than 2.0V and less than  $V_{DL}$  during discharge, and the battery is in the over-discharge protection state; the other is when the  $V_{DD}$  voltage is less than 1.5V during discharge, and the battery enters the over-discharge protection state (sleep state).

There are differences in the conditions required to restore the two states to the normal state, which are described below:

- (1) For the battery that has entered the over-discharge voltage protection state, as long as a voltage greater than or equal to  $V_{DL} + V_{HD}$  is applied to the VM terminal to charge the battery, the battery can return to the normal state.
- (2) For the battery that enters the dormant state, the charging voltage of the VM terminal must be greater than 2.0V before the dormant state can be released. At this time, the battery is continuously charged. When the  $V_{DD}$  voltage is greater than or equal to  $V_{DL} + V_{HD}$ , the battery returns to the normal state.

#### **9.5 Over-discharge current situation (detection of over-discharge current 1 and over-discharge current 2)**

Discharge the battery under normal conditions. When the discharge current exceeds the over-discharge detection current  $I_{ODC1}$  or  $I_{ODC2}$ , and the maintenance time exceeds the over-discharge current detection delay time  $t_{ODC1}$  or  $t_{ODC2}$ , CT2105 will turn off the internal switch key, disconnect the discharging circuit and stop discharging. Enter the over-discharge protection state.

*Recovery conditions:* The circuit will automatically return to normal state after disconnecting the load.

#### **9.6 Load short-circuit current situation**

Under normal conditions, when the voltage at the VM terminal of the CT2105 circuit is less than or equal to the short-circuit protection voltage ( $V_{SHORT}$ ), the system will turn off the switch within the  $t_{SHORT}$  time, cut off the discharge circuit, and enter short-circuit protection.

*Recovery condition:* By disconnecting the load, when the voltage of the VM pin is higher than the short-circuit protection voltage ( $V_{SHORT}$ ), the load short-circuit current condition will be released.

### **9.7 Charger detection**

When the battery in the over-discharge state is connected to the charger, if the VM terminal voltage is greater than or equal to the charger detection voltage  $V_{CHA}$ , and when the battery voltage is greater than or equal to the over-discharge detection voltage  $V_{DL}$ , CT2105 will release the over-discharge state. When the battery in the over-discharge state is connected to the charger, if the VM terminal voltage is greater than or equal to 2.0V and lower than the charger detection voltage  $V_{CHA}$ , when the battery voltage is greater than or equal to the sum of the over-discharge detection voltage  $V_{DL}$  and the over-release hysteresis voltage  $V_{HD}$  CT2105 will release the over-discharge condition.

### **9.8 Battery cell connection**

When B- and B+ are connected to batteries, CT2105 will decide whether to start the protection action based on the situation at the moment of connection. When the IC detects a momentary high voltage at the VDD terminal, the IC will initiate a protection action and enter the protection state. At this time, the IC will cut off the connection between the battery core and the outside to protect the battery core.

*Recovery conditions:* Use a comprehensive tester to test the battery or charge it with a charger to return to normal working condition.

### **9.9 Battery core reverse connection situation**

In actual operation, if B+ and B- are accidentally connected reversely, CT2105 will enter the cell reverse connection protection state. At this time, the internal circuit of the IC will limit the reverse current to the range of 40mA, so that the circuit will not be burned by the large reverse current.

*Recovery conditions:* Correctly connect the positive and negative poles of the battery core to the positive and negative poles of the circuit to restore to normal working condition.

### **9.10 Delay circuit**

- (1) When over-discharge current 1 is detected, the detection delay time of over-discharge current 2 and load short circuit starts to be calculated. Once the over-discharge current 2 or load short-circuit time exceeds the over-discharge current 2 or load short-circuit delay time, CT2105 will stop discharging.
- (2) When an over-discharge current is detected and the load is not disconnected beyond the over-discharge detection delay time, if the battery voltage is lower than the over-discharge detection voltage, the system will enter the sleep state. If the over-discharge voltage drops to the over-discharge detection voltage due to over-discharge current, CT2105 will stop discharging through discharge current detection. In this case, the recovery of the battery voltage is very slow. If the battery voltage is still lower than the over-discharge detection voltage after the over-discharge voltage detection delay time, the CT2105 will go to sleep condition.

### **9.11 Charger reverse connection protection and release**

When the battery is connected normally but the charger is reverse-connected, the circuit enters the charger reverse-connection protection state and the connection between the charger and the battery is disconnected. Disconnecting the charger can release the protection status.

## 10. Working sequence diagram

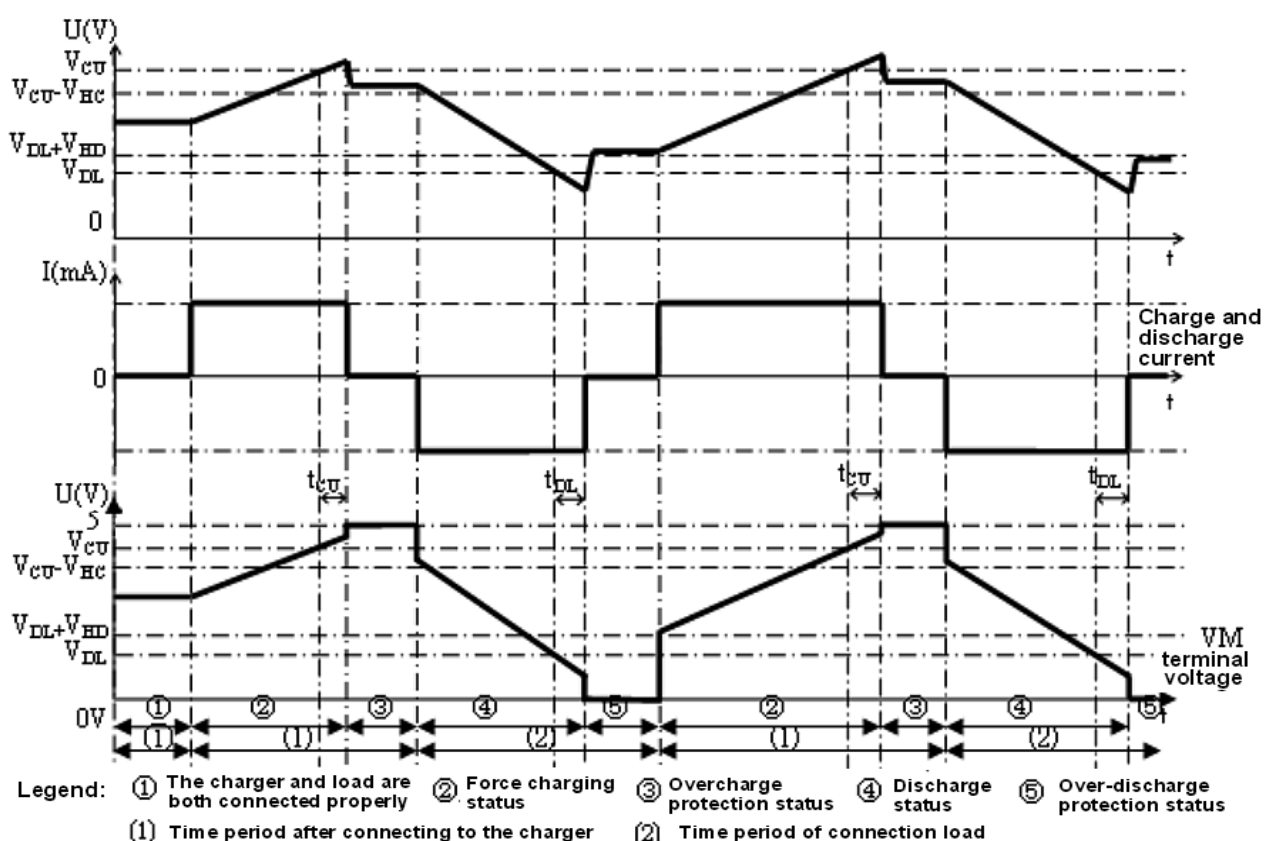


Fig. 10.1 Charge and discharge cycle. Timing diagram

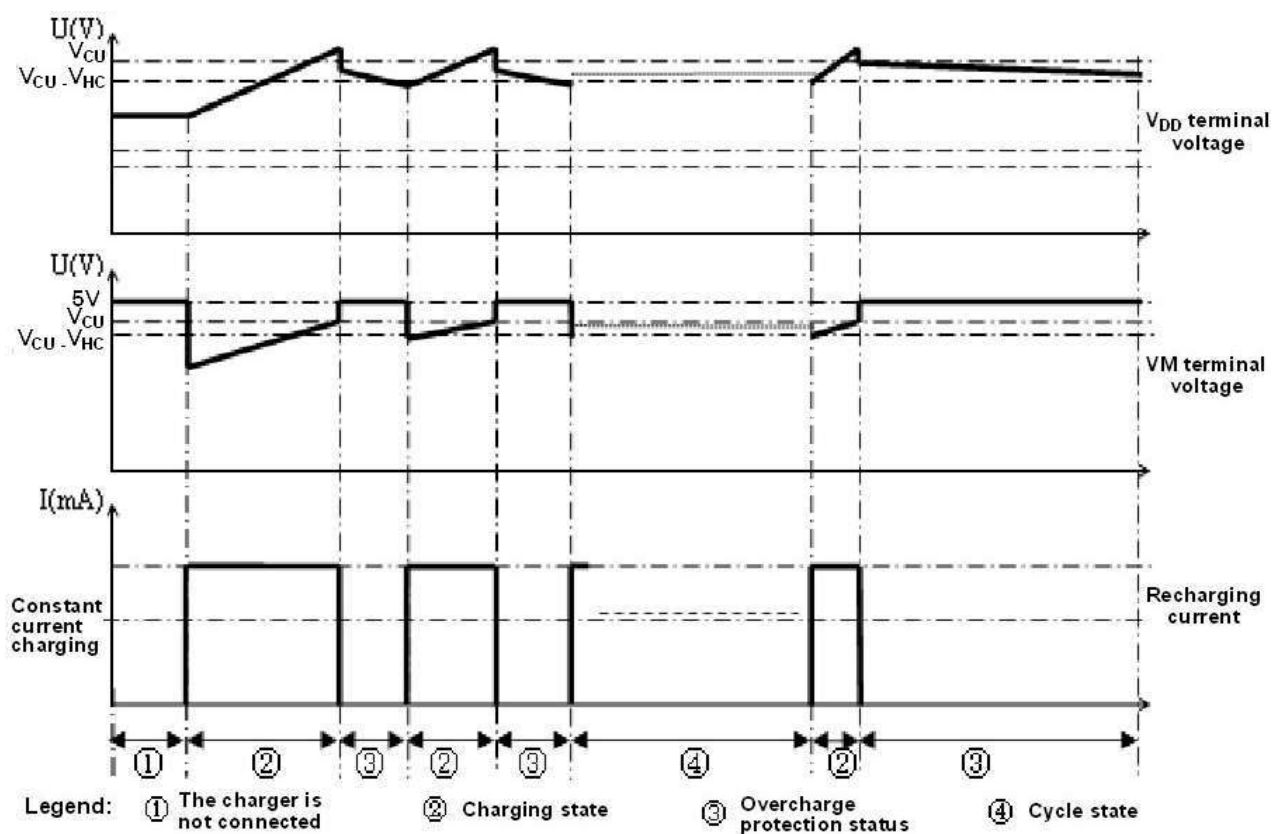


Fig. 10.2 Overcharge protection cycle. Timing diagram

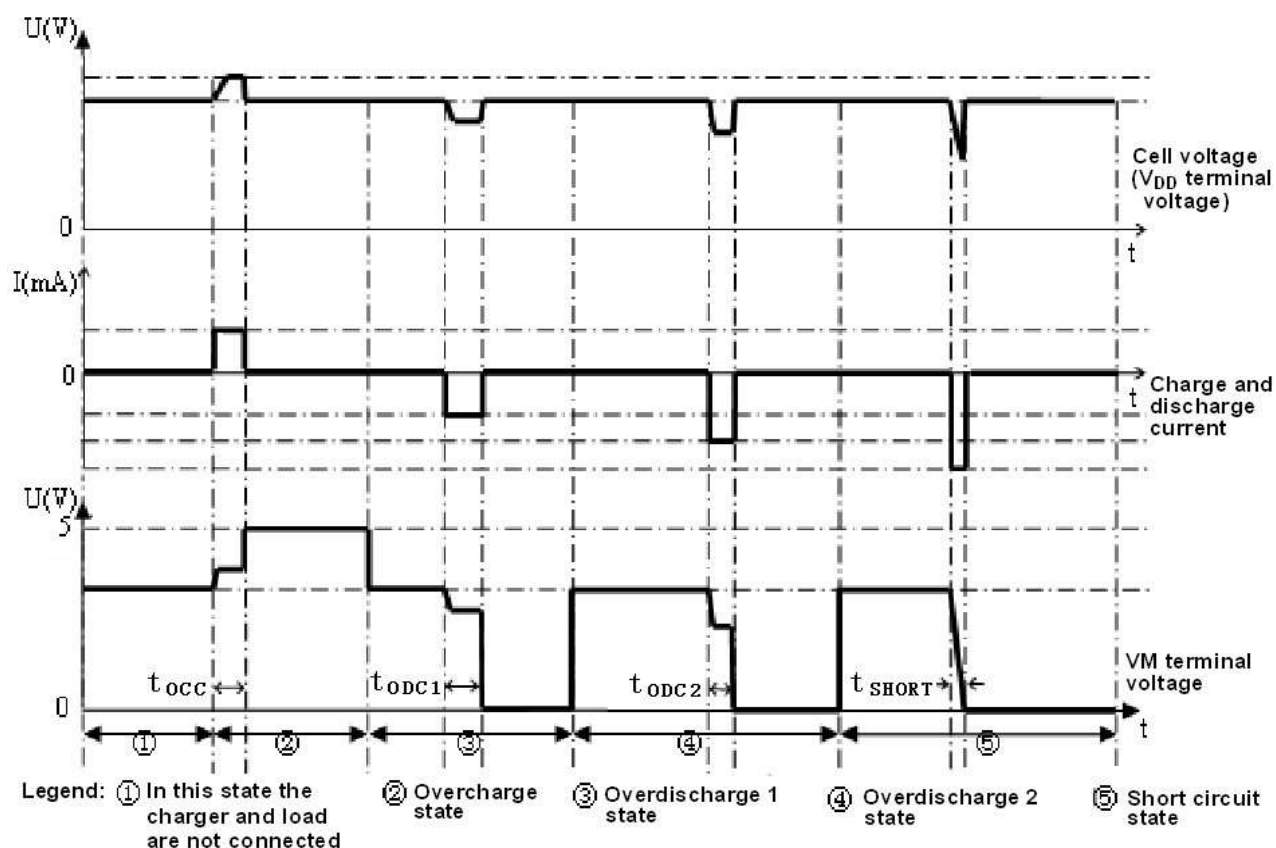


Fig. 10.3 Overcurrent and short circuit protection. Timing diagram

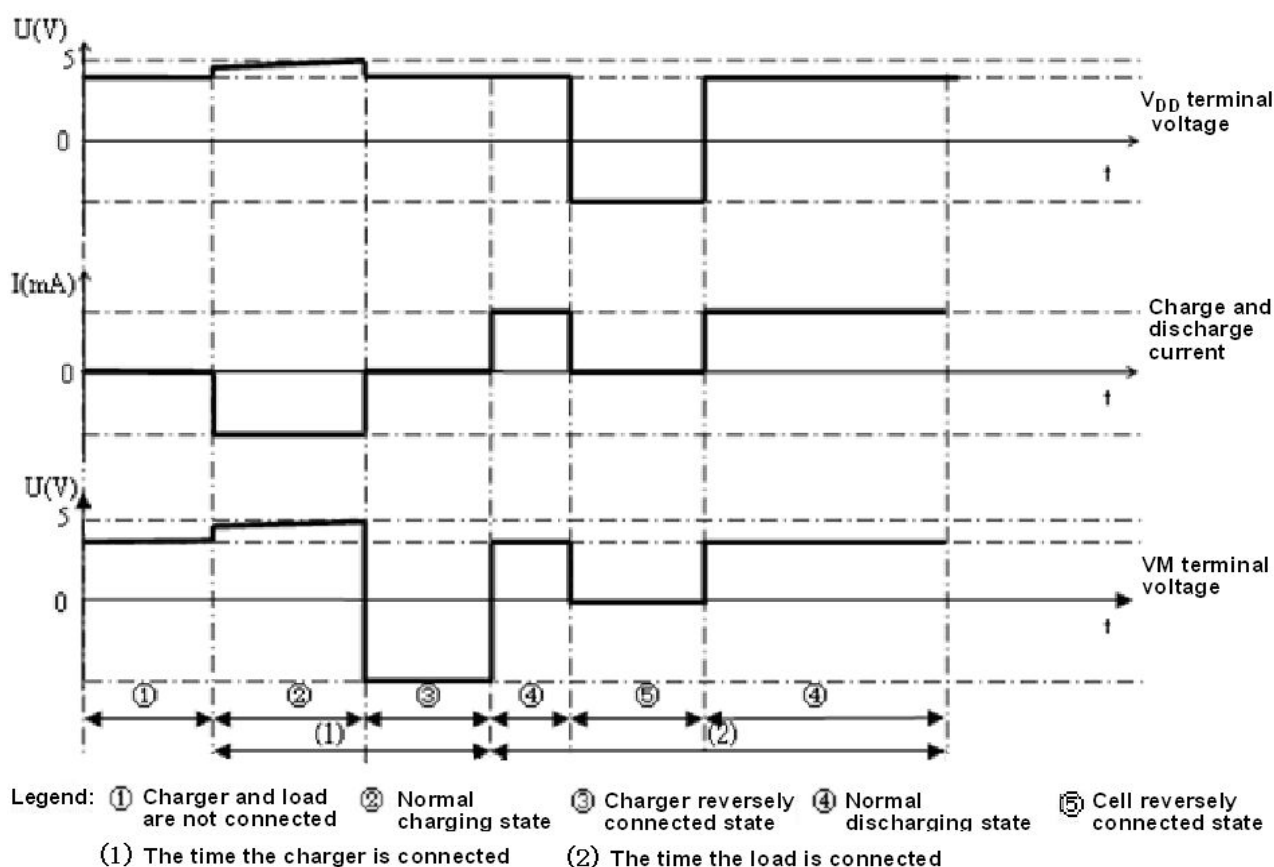
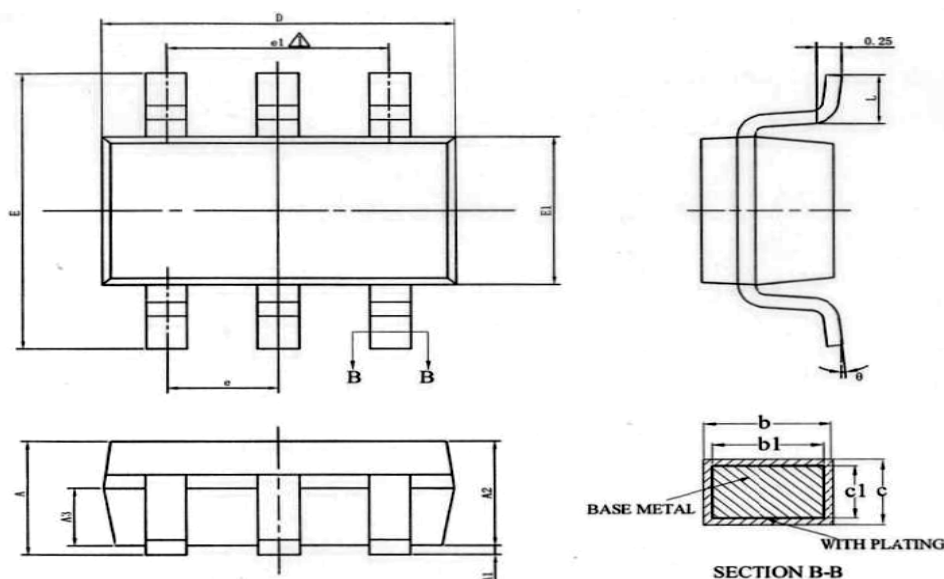


Fig.10.4 Reverse connection protection. Timing diagram

## 11. Package size



| SYMBOL           | MILLIMETER |       |      |
|------------------|------------|-------|------|
|                  | MIN        | MON   | MAX  |
| A                | -          | -     | 1.35 |
| A1               | 0.04       | -     | 1.5  |
| A2               | 1.00       | 1.10  | 1.20 |
| A3               | 0.55       | 0.65  | 0.75 |
| b                | 0.30       | -     | 0.50 |
| b1               | 0.30       | 0.40  | 0.45 |
| c                | 0.08       | -     | 0.22 |
| c1               | 0.08       | 0.13  | 0.20 |
| D                | 2.72       | 2.92  | 3.12 |
| E                | 2.60       | 2.80  | 3.00 |
| E1               | 1.40       | 1.60  | 1.80 |
| e                | 0.95BSC    |       |      |
| e1               | 1.90BSC    |       |      |
| L                | 0.30       | -     | 0.60 |
| θ                | 0          | -     | 8°   |
| L/F carrier size | 26*66      | 39*66 |      |
|                  | 52*66      | 41*72 |      |

### Product Statement:

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